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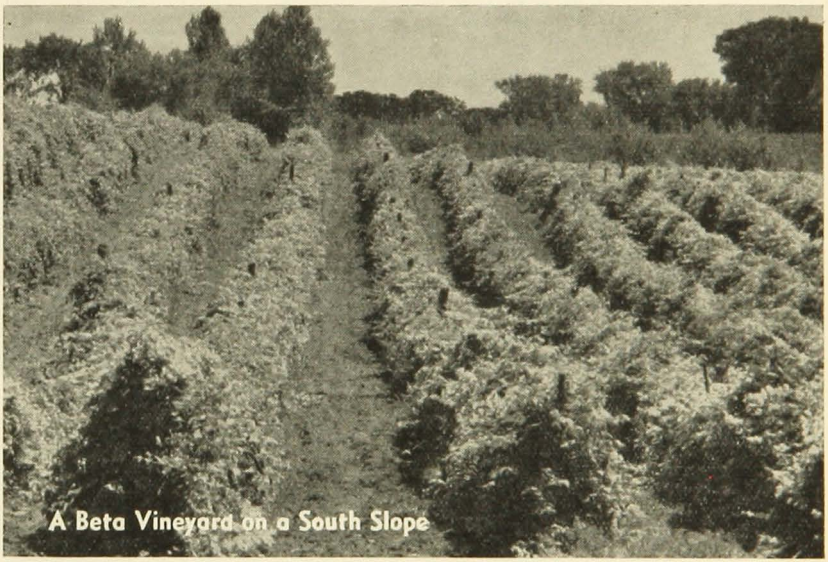
W. G. BRIERLEY and W. H. ALDERMAN



A Beta Vineyard on a South Slope

UNIVERSITY OF MINNESOTA
AGRICULTURAL EXPERIMENT STATION

Grape Growing in Minnesota

W. G. Brierley and W. H. Alderman[1]

FRUIT growers in Minnesota have been interested in grape growing ever since the time of the first settlements. Altho Minnesota has not and does not now rank as a grape-producing state, records show that a small acreage has been devoted regularly to the commercial production of this crop. This acreage and the resulting production have fluctuated greatly, owing to adverse climatic conditions or to competition with other localities. The more common older varieties derived from the eastern grape *(Vitis labrusca)* have not proved satisfactory because of lack of hardiness. Altho these grapes can be grown, frequent losses from winter injury or the increased cost of production due to the necessity for winter protection have led growers to abandon them as unprofitable. In addition, most of the varieties of eastern grapes have not proved satisfactory because the growing season generally is too short to insure full maturity and the development of a satisfactory sugar content. These difficulties were recognized at an early day by those interested in grape growing. Some of these growers began to experiment with the hardy wild grape *(Vitis vulpina)* commonly found in Minnesota, and seedlings of more or less value were obtained. As early as 1870, Louis Suelter,[2] in the town of Carver, grew some seedlings of a promising native vine which he thought had been naturally cross-pollinated with the Concord. These seedlings fruited in 1881 and one of them was named "Beta" by Mr. Suelter. Altho this variety appears to be of the *vulpina* type, and there is doubt that it is a hybrid, it has become the leading variety among hardy grapes. Beta, Alpha, and other varieties of hardy grapes have to a very large extent replaced the tender varieties in commercial vineyards. Altho it is recognized that these hardy grapes are not equal in size or quality to the eastern varieties, their ability to endure winter cold without protection has made them of considerable value in Minnesota and neighboring states.

Importance of the Grape in Minnesota

Grapes produced in Minnesota supply only a part of the local demand. As the hardy grapes are used chiefly for juice and jelly making, the supply for table use generally is obtained from sources outside the state. The fluctuation in the number of vines grown in Minnesota and the annual yield may be seen in Table 1. These figures indicate a marked decline from 1899 to 1919 in the number of vines under cultivation and in the crop produced. The figures for 1929 and 1935 indicate a renewal of interest in commercial grape growing. Planting for home use, also, has increased markedly in recent years.

[1] The authors wish to express their appreciation to F. P. Daniels, of Long Lake, for the use of his vineyard in which the experimental work on pruning was carried on during 1928 and 1929. They also wish to thank Dr. A. A. Granovsky, of the Division of Entomology and Economic Zoology, for the discussion of grape insects, and C. J. Eide, of the Division of Plant Pathology and Botany, for the discussion of grape diseases.

[2] The Beta Grape and Its Origin. Wm. Pfaender, Jr. In Minn. Hort. 40:12-14. January, 1912.

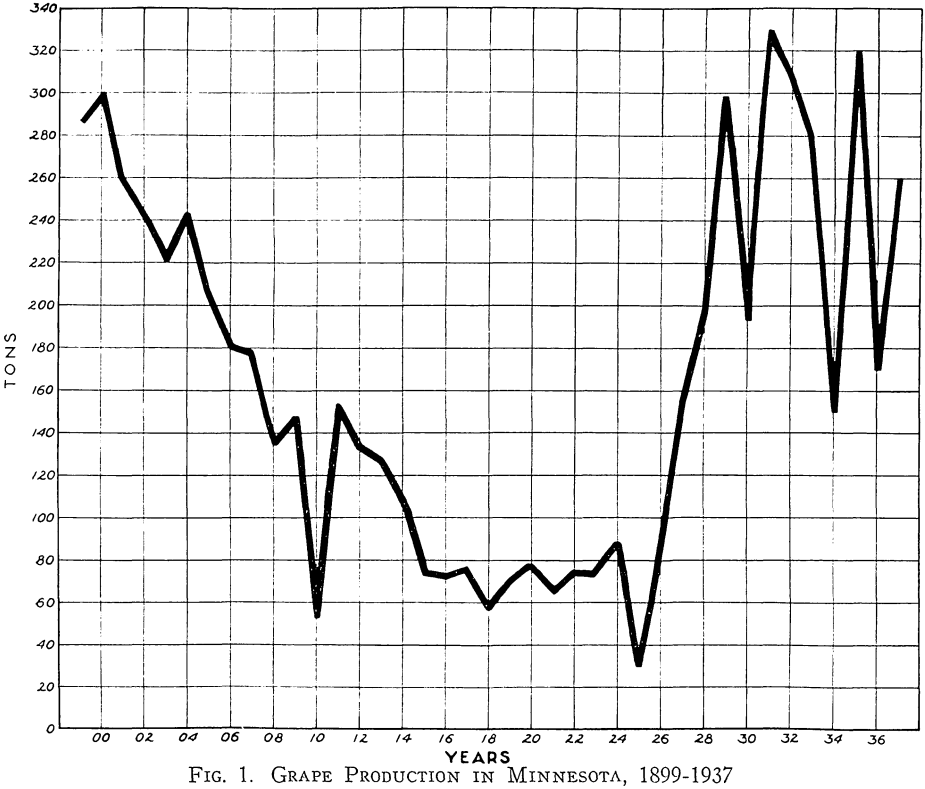


FIG. 1. GRAPE PRODUCTION IN MINNESOTA, 1899-1937
(From crop estimate data of Crops and Markets, U. S. Department of Agriculture.)

It is a part of the history of grape growing in Minnesota that the eastern varieties formerly were grown more or less extensively but that they declined owing to climatic and economic difficulties. During recent years there has been a marked increase in the planting of hardy varieties. The extent of the decline of the eastern varieties and the rise in importance of the hardy sorts are shown in Figure 1. The marked decline of the tender eastern varieties is clearly indicated. This decline may be attributed in part to winter injury and other cultural handicaps, but it is also due in large part to competition with other localities where production costs were lower. This competition was aided by the development of shipping facilities and relatively low costs of transportation. With the increases in transportation costs follow-

Table 1. Grape Production in Minnesota*

	1899	1909	1919	1929	1935
Farms reporting	.....	2,138	2,204	9,794	9,652
Bearing vines	138,175	61,916	36,315	105,941	107,863
Non-bearing vines	.....	35,950	11,863	34,237	17,633
Yield, pounds	573,272	293,805	141,278	597,895	640,000
Value	.....	$11,021	$14,134	$30,000	$19,200

* Data compiled from Census Reports.

ing the World War and the increasing demand for grapes for the home manufacture of grape juice, there has been a marked upward trend in the planting of hardy grapes and in production. The marked decreases in production in 1925 and 1930 may be attributed to winter injury and late spring frosts. Extensive winter injury to the roots was observed following the winter of 1929. This weakened the vines and contributed to the reduction in yield. In 1934 and 1936 severe drouth during the growing season markedly reduced yields. During the last ten years production has averaged about 250 tons, with increases in favorable seasons and decreases when conditions were not favorable.

It is of interest to note that in 1919 the counties leading in grape production were, in order of volume, Martin, Hennepin, Washington, Carver, and Houston. More recent census figures give the order as Hennepin, Ramsey, Carver, Dakota, Martin, Washington, and McLeod. It is obvious that grape production tends to become centered in the counties near the Twin Cities.

The figures presented in the 15th Census indicate that in Hennepin County the yield per vine averaged about 7 pounds, or a little less than 2 tons per acre. For the state as a whole the yields averaged about 1½ tons per acre. Altho these yields are fairly satisfactory, in view of the relatively low cost of handling the crop it is obvious that better management practices may result in increased yields. This has been found true particularly with regard to pruning.

Sites for Grape Growing

Careful selection of the site for grape growing is essential in Minnesota. Low ground should be avoided on account of the danger from frost and poor soil drainage. If possible, the site selected should be reasonably free from either late spring or early fall frosts. The frost-free growing season usually is not long enough to insure proper maturity in varieties such as Concord, and for the hardy varieties it is highly desirable that a site be selected that will provide the longest possible frost-free season. This may be found on slopes facing to the south or southeast. Northerly slopes should be avoided, as maturity of both vine and crop will be delayed. Higher average temperatures may be expected on southerly slopes. If other requirements for satisfactory growth are present, the warmer slopes should exert a favorable influence on maturity and sugar content of the fruit. The vines will also reach a better stage of maturity, as a rule, and the losses from winter injury will be lessened.

The advantages of southerly slopes are enhanced if they face the larger lakes or rivers which serve to protect adjacent sites against frost damage in spring or fall.

Altho a sloping site is to be preferred, it is best to choose sites that are not too steep in order to avoid soil washing. Some growers have found it possible to utilize steep slopes by terracing, but this adds materially to the cost of developing the vineyard.

The relationship between site and soil should always be kept in mind. Even the most ideal site will be of little value if the soil is not suitable.

Soils for Grape Growing

Grapes usually grow best on medium loam soils that contain a fairly high percentage of organic matter. Light sandy soil and heavy clay are not well suited for grape growing. The organic

content of the soil is of particular importance on account of its tendency to hold water for the needs of the plants. This need is emphasized on the southerly slopes that are exposed to more rapid drying from the sun and prevailing summer winds. Grapes grown on heavy soils may make a vigorous growth that will be late in maturing and may suffer severely from winter injury. Usually, very light sandy soils do not furnish enough plant food or water to the vines to provide for normal growth. Unless light sandy soils can be improved by the addition of stable manure or by the growing and plowing under of green manure crops, the use of such soils for grape growing is not advisable.

Preparation of Soil

Thoro preparation of the soil before planting is highly desirable. If cultivated crops have been grown on the site and if the soil is in good condition, little preparation will be needed other than deep plowing and thoro harrowing. If the land is in old sod or is uncultivated, deep plowing will be desirable and, as a rule, it will be advisable to grow some cultivated crop or clover on the site for at least one season until the soil is in good condition. Grapes planted on hastily or poorly prepared soil can not be expected to make a satisfactory growth, and production will be greatly lessened.

Planting Plans

For hillside planting, the rows should run across the slope to avoid washing and to make cultivation easier. On gentle slopes or level land, best results may be expected when the rows run north and south, exposing both sides of the vines to the direct rays of the sun. The rows commonly are spaced 8 feet apart but on steep slopes the distance should be 10 feet. Even wider spacing may be desirable if the grower plans to maintain strips of sod to prevent washing.

Spacing in the row varies from 8 to 10 feet. Usually no advantage is gained from crowding. Spacing at 10 feet in the row in very rich soil will provide additional room for growth. On light soils, with this spacing more food and moisture will be available for each vine.

Selecting Plants

Vigorous two-year-old vines usually give best results. They should have a well developed root system and one or two good canes. Weak vines, or those with a poor root system, can not be expected to grow and produce as well as the more vigorous ones, and the difference in the initial cost is not great. Occasionally one-year-old vines may have sufficient vigor to be satisfactory. Experience has shown that plants developed from 2- to 3-eye cuttings, with the roots deeper in the soil, are less subject to winter injury than those developed from the single-eye cuttings.

For planting 8×8 feet apart, 680 vines are required to set an acre; at 8×10 feet, 544 vines will be needed. These should be ordered early enough to insure their arrival in time for planting as soon as the soil can be prepared.

Planting

The location of rows and individual plants may be indicated by stakes or furrows or by marking. Care should be taken to run the rows straight in order that a trellis may be constructed and properly maintained. When the vineyard is planted on a gentle slope,

care in keeping the plants in line across the field will permit more thoro cross-cultivation during the first or second seasons before the trellis is constructed.

If the rows are plowed out, only a little more soil will need to be removed to give enough room for spreading the roots. If the holes are dug, they should be large enough to provide room for the roots and deep enough to establish the roots about 8 inches in the soil. The plants should be heeled in until needed for planting and care should be taken to prevent drying of the roots during the planting operation. Usually all canes are cut off except the best one. Straggling roots should be cut back and dead ones removed. Top soil should be thrown in to cover the roots and firmly tramped as the hole is filled. The surface soil should be kept loose, especially in heavy soil.

Pruning the Vines

Pruning is one of the most important practices connected with the growing of grapes, whether on a commercial scale or for home use. Some growers have their own pet methods and there is a considerable variation in the style of pruning in different sections of the country. This variability is confusing to the grower and raises a question as to what is the best method. The answer to such a question will depend upon whether the varieties are hardy and can stand winter exposure or are tender and require protection. While the form of the vine is modified to meet these conditions, the general principles involved are the same in all cases.

Grapes differ from tree fruits in that they bear only on new wood of the current season's growth, and while this wood will never fruit again, it does produce the buds from which spring the following season's fruiting canes. With this habit in mind, the following points should be carefully observed: (1) They require very heavy pruning each year to remove useless wood that has already fruited; (2) only a few of the strongest new canes should be left to bear fruit; (3) each normally vigorous bud on a new cane will produce a shoot that will carry two clusters of grapes, on the average; (4) old wood should be reduced to the minimum necessary to carry the new canes; (5) leaving too much fruiting wood reduces the size of the bunches.

Time of pruning.—Tender grapes should be pruned in the late fall preparatory to laying them down and covering them with soil just before the ground freezes. Hardy grapes may be pruned either late in fall or early in spring before the buds begin to swell. Pruning in late spring causes excessive bleeding, which is not necessarily serious in its effects but is usually disquieting to the owner and is probably somewhat weakening to the plant.

Pruning at planting time.—All grapes, when planted, should be cut back to one cane and that shortened to a few inches on which there must be two or three buds. The roots may be cut back slightly, removing all broken ones and frayed ends.

Pruning hardy grapes.—The standard four-cane Kniffin system commonly used in near-by states has generally been adopted for the hardy grapes of Minnesota. A growing suspicion that this system might not be the best for the smaller clustered varieties of the Beta type led to a preliminary pruning test with a few vines in 1928. The vines in Plot 1 were pruned to the usual four canes, totaling from 13 to 15 feet of fruiting wood and carrying about 3½

buds per running foot. The vines in Plot 2 were pruned to six lateral canes, which increased the amount of fruiting wood by approximately 50 per cent. The vines in Plot 3 were pruned to eight canes, thereby increasing the amount of fruiting wood 100 per cent. Double trunks were used when necessary to secure the required amount of fruiting wood. As indicated in Table 2, the amount of wood actually retained in 1928 in the six- and eight-cane plots was somewhat in excess of the theoretical amounts sought. It is to be noted that the increase in cane length was accompanied by a substantial increase in yield per vine.

Table 2. Yields of Beta Grapes in 1928 and 1929

No. of canes	1928		1929	
	Length of canes, ft.	Yield, lb.	Length of canes, ft.	Yield, lb.
4	14	9.35	13.0	9.75
6	27	13.73	20.4	13.39
8	33.6	15.04	26.6	14.57

The experiment was repeated in 1929 on a larger scale with replicated plots, permitting a more satisfactory analysis of the data. It will be noted from a study of Table 2 that in 1929 in the six-cane plots the bearing wood was actually increased by 57 per cent and in the eight-cane plots by 105 per cent over the amounts carried by the standard four-cane series. The yields were strikingly similar to those of the preliminary test. The gain in vine yield, however, did not keep pace with the increase in bearing wood. An increase of 57 per cent in bearing wood produced an increase of 37 per cent in yield, while increasing the wood 105 per cent increased the yield only 49 per cent. This falling off in rate of increase is to be expected and indicates that the production curve as related to the amount of fruiting wood retained is rapidly flattening out and that 20 to 25 feet of fruiting wood with 70 or 90 buds is probably about the maximum that should be retained for a Beta vine in average vigor.

Table 3 indicates the effect of increasing the amount of fruiting wood upon the number of clusters per vine and the size of the cluster. As would be expected, the increase in yield is accounted for by the increase in number of clusters per vine made possible by the additional number of fruiting shoots developed. The increase in number of clusters was relatively greater than the increase in weight of fruit. In the six-cane plots the gain in production was 37 per cent, compared to a gain of 44 per cent in number of clusters. In the

Table 3. Effect of Pruning Upon Number and Size of Clusters

No. of canes	Clusters per vine	Weight of cluster, oz.	Loss in weight of cluster, per cent
4	60.9	2.26	0
6	99.3	2.16	4.4
8	110.6	2.09	7.5

eight-cane plots the increases were 49 per cent and 62 per cent, respectively. The reduction in size of clusters is relatively small when considered from the standpoint of the individual bunch, the reduction being 4.4 per cent for the six-cane plots and 7.5 per cent for the eight-cane plots. In the production of high-grade table grapes, such a loss might be important; but of grapes used for juice and culinary purposes, total yield assumes greater importance than size of cluster.

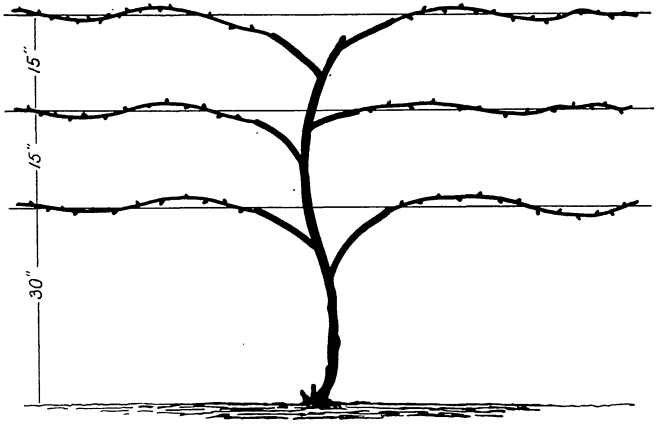


FIG. 2. DIAGRAM OF SIX-CANE KNIFFIN SYSTEM

On the basis of the data secured from these experiments, it is recommended that the four-cane Kniffin plan be modified to provide six fruiting canes (three on each side). This requires a three-wire trellis as indicated in Figure 2. At the beginning of the second growing season, all new canes should be removed except one of the strongest and this should be tied to the wires in an upright position. It should be cut off just above the top wire if its length exceeds this distance. In the event of weak growth the first season, the vines should be headed back to the middle or lowest wire or to three or four buds as at planting. If this treatment is necessary, a vigorous cane may be utilized to develop a strong trunk the following year.

During the second summer, lateral shoots will be produced and possibly a cluster or two of grapes, but these should not be expected from so young a vine. At the next pruning, all but six of the canes should be removed and these six cut back to about 18 inches. They are then tied to the wires in the form indicated in the diagram. (See Figure 2.)

During the third season, several shoots will grow out from these short canes, some hanging down and others running along the wires. A light crop may be expected that year. Following this season, strong canes should be selected that start from as near as possible to the base of the original arms. These canes should be cut back to about 2½ feet and will form the framework for the succeeding year. The wood beyond these canes should be removed.

Any weaker growth between the canes selected and the trunk, or surplus canes arising from other points on the trunk, should be cut back to short spurs, leaving only one or two buds. The shoots coming from these buds usually will not produce much fruit but will produce new canes, which may aid

materially in the selection of the framework when the vines are pruned the next fall.

Following the fourth and succeeding years, the canes may be cut to 3 or 3½ feet. Canes springing from as near as possible to the upright trunk should always be selected, thus renewing each year as large an amount of the vine as possible. After several years the trunk itself may become knotty and gnarled so that the sap does not flow through it easily. Advantage may often be taken of a strong shoot starting from near the roots to renew the entire trunk and vine when such a condition arises.

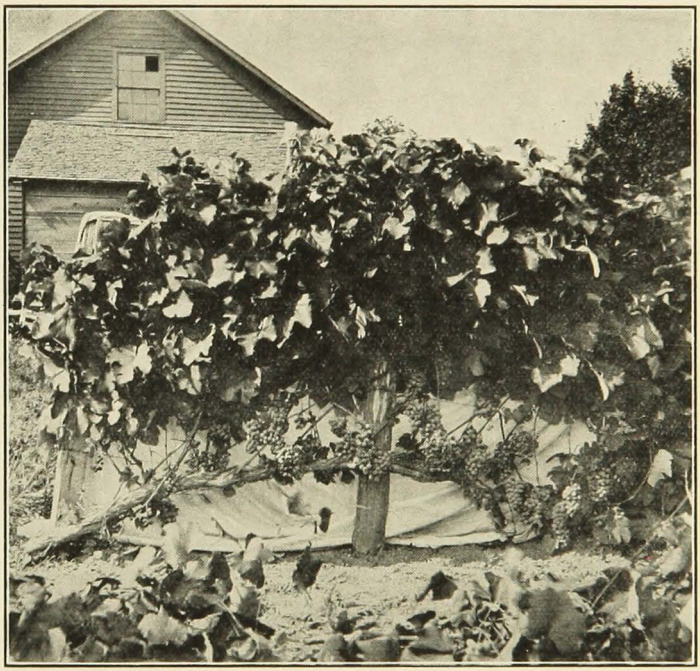


FIG. 3. TENDER VINE TRIMMED WITH A HORIZONTAL TRUNK

Pruning tender grapes.—Varieties like Campbell (Early), Moore (Early), Concord, Delaware, and many others, require winter protection in most parts of Minnesota. This compels the formation of a vine that can be removed easily from the trellis and covered with soil without much danger of breaking the canes. The best method yet devised to meet these conditions is illustrated in Figure 3. This method should also be used for hardy grapes when grown in northern Minnesota, where winter protection is necessary. The vine should be planted at an angle and the shoot selected for the main trunk should start at a narrow angle from the ground so that it may be lowered and covered each fall with a minimum amount of bending.

If a weak growth is made the first season, it is probably best to cut the vine back to a single cane a foot or less in length and wait for the following

year to produce a vigorous young trunk. It often happens, however, that the first year's growth produces a vigorous cane that may be cut back to 24 or 30 inches to form the beginning of the permanent trunk. The next season this is raised from the ground and tied to the lowest wire. As side shoots start from this, they are tied from time to time in an upright position to the upper wires. In the fall a few of the laterals are cut back to form short spurs and the trunk is elongated somewhat by bending down the cane nearest the extremity. By the end of the third or fourth season the trunk should have obtained its full length (usually 6 or 7 feet). An attempt should be made each year to renew the spurs as much as possible. After several years it may be desirable to renew the entire trunk by a cane from near the base if the original has become badly knotted. When the vine is in full bearing, at least two fruiting shoots should start from each spur each season. The amount of fruiting wood a vine carries may be gradually increased from year to year until the plant is about five years old, when it may carry the maximum amount. A disadvantage of this system of pruning is the necessity of going over the vineyard every week or ten days during the early part of the growing season and tying the shoots to the upper wires to keep them from falling to the ground. In the Kniffin system, used for hardy grapes, this repeated tying is not required, as the fruiting shoots hang downward from the canes. Such a form, however, is difficult to bend to the ground and cover without breaking or injuring the vine and is consequently not adapted to tender grapes.

Trellises for Grape Vines

During the first season the vines may be allowed to trail on the ground, but most growers prefer to drive a light stake at each vine to which the shoots may be tied. Tying in this manner insures against the breakage of shoots and permits thoro cultivation. Sometimes the stakes are used in the second season. As a rule it is best to establish the permanent trellis for the third season, and it is often desirable in the second season.

Support posts for the trellis may be of any suitable or available material, such as wood, old pipe, concrete, or angle iron. Where wood posts are cheap enough, they make a satisfactory support. Good posts may be made from old pipe, but the cutting and drilling for the wires add to the cost. Patented angle iron fence posts make a good trellis if the posts are long enough for the type of trellis desired and if properly set.

The end posts will need to be longer and larger than those used for support in the row. They should be set firmly and properly braced, as they have to carry the strain of the tight wires. Wooden posts will need bracing of the type used for fence corners or end posts. Iron end posts may be set in concrete and when properly set and braced are entirely satisfactory. All posts except those at the ends usually are driven into place unless the soil is stony. The patented type of iron post is easily handled for this purpose. Usually support posts are set in alternate spaces between the vines. With vines 8 feet apart, this will mean setting posts at 16-foot intervals.

The wire from the trellis should be galvanized to avoid rusting and strong enough to support the heavy load and

wind strain. No. 10 wire has been found to be most satisfactory, altho No. 12 may be used for the middle and lowest wires. All wires should be stretched taut when placed on the trellis. They should be tightened in the spring if they have become slack.

The spacing of the wires on the trellis will vary with the training system. For the six-cane Kniffin system the lowest wire should be 30 inches from the ground. The middle wire should be 15 to 18 inches above the lowest, and the upper wire 15 to 18 inches above the middle one. For tender grapes, the first wire should be 12 to 18 inches from the ground, the second 18 inches above the first, and the top wire 18 to 24 inches above the second.

Variations may be made in the spacing of posts and wires but the grower should realize that it is poor economy to use too short posts or too light wire. Unsatisfactory support of the vines on a low trellis is not easily corrected and light wires lead to unnecessarily heavy expense for repairs. For convenience in working the vineyard and because of the strain on wires and end posts, it is not advisable to run the trellis over 400 feet. This point should be kept in mind and the vineyard laid out accordingly.

Cultivation of the Vines

One of the essentials of grape growing is thoro tillage. The soil should be plowed in the early spring, followed by frequent cultivations during spring and early summer. Some hand hoeing will be necessary to keep the rows free of weeds. One of the chief benefits of cultivation is the control of weeds. As weeds remove a considerable amount of soil water it is desirable to keep them under control, especially on southerly slopes where soil moisture must be conserved for the use of the vines. Cultivation is not recommended after the middle of August. Late cultivation may result in late growth, which will not become properly matured and severe winter injury to the new canes may follow.

Cover Crops

Seeding about the middle of August to oats, rape, or some other cover crop that will kill out during the winter will meet several needs of the vineyard. In most cases maturity will be hastened. A ground cover will help to prevent soil washing. A well established cover crop will hold the snow in the winter or serve as a mulch to protect the roots if the snow is blown off. In Minnesota this benefit alone makes cover crops desirable for the upkeep of vine vigor. Plowing under the cover crop in the spring will help to maintain the desired amount of organic material in the soil.

Fertilizers

Stable manure will be beneficial when available. Manure adds plant food to the soil and also helps to maintain the supply of organic matter, which will retain moisture. Manuring in the summer should be avoided, as late growth and immaturity may result. When manure is not available, cover crops must be depended upon to maintain the organic matter in the soil. Commercial fertilizers may be beneficial as a supplement. Such materials, however, are not cure-alls and should be used advisedly. In good soils the benefits from fertilizers may not be sufficient to pay for their use. In less fertile soils nitrogenous fertilizers such as nitrate of soda or sulphate of ammonia may greatly improve growth

vigor. Complete fertilizers may be beneficial at times. In all cases fertilizers should be applied early, before growth starts. Later applications may result in immature growth, which will be more likely to suffer from winter injury.

Harvesting the Crop

It is desirable to allow grapes to ripen as much as the season and site permit in order that the sugar content may be fully developed. In some seasons early hard frosts may necessitate harvesting before full maturity has been reached, but light frosts will do little harm if the foliage is not seriously injured.

Practically all juice grapes grown in Minnesota are marketed locally in market baskets of about one-third bushel capacity or in half-bushel baskets. Altho these packages are large, they are fairly satisfactory for local markets. Packages such as 4- or 8-pound grape baskets may be more suitable for fancy table grapes.

The bunches are cut from the vines and placed directly in the baskets. The fruit will settle considerably as the stems wilt and dry. Filling the baskets heaping full will allow for this settling and make repacking unnecessary.

Winter Injury

Grape shoots usually grow until frost kills the tips, and the short growing season in Minnesota may result in frost injury to a considerable length of immature wood at the ends of the shoots. In some seasons this makes pruning to a definite system somewhat difficult. Usually, however, on well selected sites, if the vines are in good vigor the loss of the tip region by frost damage is not a serious matter.

Serious damage to the roots may occur more or less frequently when there is no snow cover, when the soil is sandy, or when tender varieties are grown. Under such conditions, varying degrees of root injury may occur. Observations indicate that the greatest amount of killing occurs in the cluster of roots which arise from the first node below the soil surface. Usually there is less injury to the roots arising from the successively lower nodes of the original cutting. In severe cases the roots may all be killed, leaving only the original cutting portion and an enlarged callus. Whenever root injury occurs, there is a marked decline in vine vigor. In severe cases the vines make only feeble growth in the following season or are killed.

The relative amount of root killing in the hardy and tender varieties has not been determined, but the general decline in the importance of the tender grapes, as shown in Figure 1, may be attributed in part to this cause. Injury to the hardy varieties occurs frequently enough to make protective measures desirable. As the cluster of roots arising from the first node seems to be most subject to injury, it appears desirable to avoid the use of single-eye cuttings in propagating new vines. Vines developed from this type of cutting may be expected to suffer more severely from root killing than those grown from cuttings with several buds. A wider use of cover crops to aid in maturing the shoots, to provide ground cover, and to hold the snow appears to be highly desirable. The protection provided by the cover crop should go a long way in avoiding root killing and the resulting loss in vine vigor.

Winter Protection

For the tender varieties, some form of winter protection is desirable. Usually it is best to cover the vines with 6 to 8 inches of soil. The horizontal trunk and spur training system is adapted to soil covering. After the vines are pruned in the fall, a shallow trench is opened along the row. A spade full of soil may be removed close to the base of the vine so that it can be bent more easily. The vines are then bent down carefully into the trench and mounded over with dirt. This is a laborious process, especially as it is necessary to mound up over the base of the trunk, which cannot be bent low. Except for the soil removed when the shallow trench is made, all the dirt for covering should be taken from between the rows so that the roots may not be unduly exposed. Instances have been noted in which the soil for covering was taken close to the crown of the vines with the result that the roots were severely injured and the labor and expense of covering was useless. It is considered desirable to protect the hardy varieties, in the northern part of the state, making use of the same method of covering. In the southern part of the state it may be desirable to protect the young vines of the hardy varieties during the first and second winters.

The soil must be removed from the vines in the spring before growth starts. The usual practice is to remove most of the soil about the middle of April, leaving enough barely to cover the vines. When the buds break, the rest of the soil should be removed and the vines lifted and tied in place on the trellis.

Varieties for Minnesota

Altho the tender eastern varieties formerly were grown extensively, they are now grown very little for market, but to a limited extent for home use. For market production, chief dependence is placed upon the Beta. Other hardy varieties, such as Alpha, Janesville, and Hungarian, may be found in some vineyards. Alpha and Beta are so similar in appearance that they are difficult to distinguish and doubtless have become intermixed. A few hardy seedlings have been produced in recent years, but their commercial value remains to be determined.

Hardy Grapes

Alpha.—A wild seedling transplanted by Brother William in 1901 to his vineyard at St. Johns University, at Collegeville, Minnesota. Introduced about 1910. Hardy, vigorous, productive, early. Similar to Beta, with which it is often confused. Said to be of somewhat better quality than Beta.

Beta.—Grown from seed by L. Suelter, Carver, Minnesota. Introduced about 1881. Hardy, vigorous, productive, early. Bunches medium to small, moderately compact to loose, sometimes shouldered. Berries below medium in size, black, with blue bloom, quality fair. Probably from *V. vulpina,* altho introduced as a *vulpina* x *labrusca* hybrid. The most important variety for Minnesota planting.

Hungarian.—A hardy, moderately productive variety of unknown origin. Possibly a hybrid of *V. labrusca* x *V. vulpina.* Very similar to Janesville. Clusters small, compact; berries below medium size, black, medium bloom; flavor markedly sweeter than Beta, quality fair.

Janesville.—Grown from seed of unknown parentage by F. W. Loudon, Janesville, Wisconsin. Apparently a cross between *labrusca* and *vulpina*

varieties. Named in 1868. Hardy, very vigorous, productive, slightly later than Beta. Bunches medium to small, usually shouldered, compact. Berries of intermediate size, black with heavy blue bloom. Quality fair.

Tender Grapes

A wide selection among the varieties of tender grapes is possible for those who have a specially favorable site, or for the home fruit garden. They are of value in the southern part of the state but are too tender for the northern part. As a group, these varieties ripen later than the hardy ones. In some seasons they will not reach full maturity before the foliage is killed by severe frosts. Failure to mature is more common with late varieties such as Concord and Niagara.

The varieties that have been grown most commonly are grouped on the basis of color in the list given below.

Black (or Blue)

Campbell (Early) Worden
Moore (Early) Concord

Red

Brighton Lucile
Agawam

Green (or White)

Winchell Niagara

Spraying the Vines

Grape diseases and insects may not be troublesome enough in Minnesota vineyards to necessitate a complete spray program every year. Every grower should be able to recognize the important pests and know what control measures to follow. A good spray outfit should be available so that if a pest that may be controlled by spraying becomes troublesome the applications can be made promptly. The best control usually is obtained by using the proper materials at the correct time. The type and capacity of a spray outfit to use will depend upon the size of the vineyard and upon other fruits grown. The grower who has a spray outfit for use with other kinds of fruit probably can use it for grape spraying. To be most satisfactory, the spray outfit should be capable of developing high pressure so that the spray produced will be a fine mist, which will better cover the foliage. In the following paragraphs, brief descriptions are given of the diseases and insects most likely to prove troublesome, together with suitable control measures.

Grape Diseases

Downy Mildew.—This is undoubtedly of first importance. This disease usually makes its appearance in Minnesota during the first part of July and is most prevalent in moist seasons. The early symptoms are pale yellow spots of variable size and shape on the upper surface of the leaves. The spots may appear more transparent than the rest of the leaf when it is held up to the light. Later, areas on the lower side of the leaf corresponding to these spots will become covered with a downy milk-white growth which gives the disease its name, "downy-mildew."

As the fungus lives through the winter on the old leaves, they should be raked up in the fall and burned. If the vines are attacked regularly, however, do not depend solely on this precaution. Spraying is the best method of control. Bordeaux mixture 4-4-50 should be used and applied several times each season. High pressure should be used to obtain best results. Sprays applied after the disease appears may hold it in check but can not repair the damage done.

Black rot.—Black rot may frequently cause losses to grape growers in Minnesota. It first appears as reddish brown spots on the leaves. Small black dots appear later on these spots. On the fruit the fungus causes a rapidly spreading whitish lesion which also soon becomes covered with black spots. The lesion rapidly covers the whole berry, leaving a wrinkled mummy in a week or two. Green twigs are often affected, the disease appearing as a dark depression one-eighth of an inch to one inch long, and oval or elongated in shape.

Like downy mildew, black rot is most injurious in warm damp seasons. Spraying with Bordeaux mixture[3] is the best known means of checking it. Follow the same spray schedule as for downy mildew.

Grape anthracnose.—Grape anthracnose has been reported several times in Minnesota. It affects all green parts of the vine, but it is most common on the shoots and berries. On the shoots, the symptoms are brown depressed areas one-eighth to one-half inch long. Later the center becomes gray. On the berries, spots appear that are brown around the edge, but turn gray in the center, giving them the name of "bird's eye" spots. The berries finally wither and become dried mummies.

Diseased wood should be pruned away, since the fungus spreads from such twigs to the rest of the vine. The regular spray program of Bordeaux mixture 4-4-50 should also be followed.

Grape Insects

Grape leaf hopper.—This insect has caused a great deal of injury to Minnesota vineyards, particularly in recent years. Severe outbreaks usually occur in hot, dry seasons, but in cool, rainy seasons much less damage may be expected.

The adult leaf hopper is very small, changing from lemon-yellow with dark markings and red stripes in the spring to salmon-yellow with dark orange-red markings in late summer. They spend the winter in weeds and grass or in brush or other litter near the vineyard. In early May they begin to feed upon the under side of grape leaves, particularly those close to the ground. The females deposit their eggs in the leaf veins throughout the season, from June to September. The eggs hatch within two weeks and the nymphs pass through five stages of development before reaching the adult stage. Usually there is only one generation with a partial second brood in favorable seasons. They may, however, become exceedingly numerous in hot, dry seasons and cause serious damage to the vines. The leaves are injured by the feeding punctures and much of the green coloring matter is removed. This results in a bleaching or browning of the foliage and premature drying. Badly infested vines are seriously weakened, so that crops are greatly reduced in volume and quality and the weakened vines may suffer from winter injury.

[3] Bordeaux mixture is made by dissolving 4 pounds of copper sulphate in water and either 4 pounds of stone lime slaked in water or 6 pounds of hydrated lime mixed in water. The solutions should be diluted considerably before pouring them together. The greater the dilution, the better the resulting mixture. With a 50-gallon barrel outfit, the barrel can be filled about half full of water and the copper sulphate solution added. After this has been thoroly stirred, the diluted lime solution should be poured in through a fine-mesh sieve while the mixture is constantly stirred. After sufficient water has been added to fill the barrel, the mixture is ready for use. Larger volumes are made up in a similar manner. Stock solutions may be prepared when much spraying is to be done. Copper sulphate "snow," a finely ground form of this material, will dissolve readily in cold water. Copper sulphate crystals, or "blue-stone," dissolve very slowly in cold water. It is advisable to make a stock solution if the latter form is used.

Burning any weeds, grass, or other litter and rubbish that collects near the vineyard is a very important item for the control of the hibernating insects. This should be done in the late fall or very early spring. During the growing season it may be necessary to make several applications of nicotine sulphate or "Black Leaf 40." This material should be used at the rate of one-half pint to fifty gallons of water, or this amount may be added to the 4-4-50 Bordeaux mixture used in the control of fungous diseases. It is necessary to drench the under side of the leaves where the insects are feeding, also to spray both sides of the row at the same time to prevent the insects from escaping to adjacent rows.

Grape phylloxera.—This native insect, often called the grape root-louse, is widely distributed and often attacks vineyards in Minnesota. As the native grapes are resistant to attacks of the root form of this insect, the damage is largely confined to the foliage. In the early spring, the young plant lice crawl to the upper side of young leaves and begin feeding by inserting sucking mouth parts into the leaf tissues. These feeding punctures at first produce a depression in the leaf, followed by the development of a small gall on the under side. In these galls the females grow to maturity and deposit from 500 to 600 eggs. These eggs soon hatch and the young crawl to new leaves where new galls are produced. From 5 to 7 generations may be produced in a favorable season and a large number of galls may be seen on the leaves. In the latter part of the season, some of the young migrate to the roots, where they go through other development stages and over-winter, to renew the infestation of the foliage in the following season.

No satisfactory control measures are known that are applicable under Minnesota conditions. Fortunately, severe infestations are infrequent and the insect does not appear to weaken the vines as seriously as does the leaf hopper.

Grapevine fleabeetle.—This is a very small beetle of a greenish or dark steel-blue color. The adult feeds on the dormant buds and prevents growth. Eggs are laid in early warm weather and hatch in two or three weeks. The larvae or grubs eat holes in the leaves and sometimes feed on the blossoms. The fully grown grubs drop to the ground and enter the soil, where they pass through the pupal stage, which lasts about ten days, after which a new generation of beetles emerges and feeds on the foliage. With the approach of cold weather they hibernate along the borders of hedges, woodlots, fence lines, or other waste places. Cleaning up around the vineyard as recommended for the control of the leaf hopper is also the best control for this insect. The grubs are easily controlled by spraying with arsenate of lead at the rate of 1½ pounds to 50 gallons of water. The beetles feeding on the buds in the spring may be controlled by the same spray to which a half gallon of molasses is added.

Rose chafer.—This insect, which feeds on a large number of plants, is found at times feeding upon the blossom clusters, newly set fruit, and young foliage of grapes. The beetles are about ½ inch long, light chocolate in color, and troublesome especially to grapes grown in sandy soil. Hand picking of the insects may be practiced for a few vines, but in larger vineyards the sweetened spray recommended for fleabeetles is usually effective, altho two or more applications may be necessary.